International Journal of Engineering

Journal Homepage: www.ije.ir

Comparison of Single-stage and Two-stage Tubular SOFC-GT Hybrid Cycles: Energy and Exergy Viewpoints

N. Shokati*, F. Ranjbar, F. Mohammadkhani

Faculty of Mechanical Engineering, University of Tabriz, Tabriz, Iran

PAPER INFO

Paper history:
Received 15 April 2014
Received in revised form 01 March 2015
Accepted 13 March 2015

Keywords:
Tubular Solid Oxide Fuel Cell
Efficiency
Gas Turbine
Exergy Destruction
Exergetic Performance Coefficient
Hybrid Cycle, Parametric Study

ABSTRACT

In this work, single-stage and two-stage tubular solid oxide fuel cell /gas turbine (SOFC-TG) hybrid cycles are comparatively examined from the energy and exergy viewpoints. For this purpose, mass, energy and exergy balances are applied to all components of the cycles. The behavior of tubular solid oxide fuel cell modeled in this study is validated with the experimental test data of tubular SOFC developed by Siemens Westinghouse. The results of simulation show that two-stage SOFC-GT hybrid cycle not only generate more power, but also it has high efficiency in comparison to single-stage SOFC-GT. The values of first law efficiency and exergetic performance coefficient (EPC) are increased from 60.69% and 1.405 in single-stage SOFC-GT to 63.93% and 1.725 in two-stage SOFC-GT, respectively. This means that for equivalent generated power of single and two-stage SOFC-GT hybrid cycles, the amount of exergy destruction for two-stage SOFC-GT cycle is less than single-stage SOFC-GT. Also, exergy destruction of all components of the hybrid cycles is calculated separately and the results are compared. Finally, a parametric study is performed to find out optimal values for solid oxide fuel cell design parameters. Effects of these parameters are evaluated on efficiency, generated power and total exergy destruction of the hybrid cycles.

doi: *10.5829/idosi.ije.2015.28.04a.17*

1. INTRODUCTION

It is expected that hydrogen fuel be one of the main sources of producing energy all over the world in future years. Fuel cell is an electrochemical device in which a high-quality electric energy will be produced due to the reaction of hydrogen and oxygen. Hence, fuel cell will be one of the sources of producing power and energy in the future [1]. Nowadays, solid oxide fuel cell is the main option in power plants, because in addition to the general advantages of fuel cells, its special advantages such as more efficient in comparison to other fuel cells, the possibility of reforming input fuel in the stack of fuel cell, no need to expensive catalysts and its low corrosion due to the use of solid electrolyte in its structure have increased the usage of this kind of fuel cell in comparison to other kinds of fuel cells. The idea of combining different power cycles to optimize and lessen energy losses has been taken into consideration for a long time. Due to high operating temperature, solid oxide fuel cells pave the way for the exhaust gasses of the fuel cell to be used as a heat source for other cycles. One of these measures is the combination of solid oxide fuel cell (SOFC) with gas turbine cycle. The use of SOFC was introduced by Yoshida and Ide [2]. In the gas turbine cycle, combustion chamber contains the most amounts of losses. If we can prevent direct contact of air and fuel in the combustion chamber, we can reduce the total losses in the cycle remarkably and as a result more efficiency will be expected. Therefore, using the fuel cell in a gas turbine cycle can lead to both having a power plant with less pollution and also increasing its efficiency. Much research has been done in the field of SOFC and the SOFC-Gas Turbine combined cycle. Combining solid oxide fuel cell with a micro gas turbine by Siemens- Westinghouse Company

*Corresponding Author's Email: n_shokati@tabrizu.ac.ir (N. Shokati)

Please cite this article as:N. Shokati, F. Ranjbar, F. Mohammadkhani, Comparison of Single-stage and Two-stage Tubular SOFC-GT Hybrid Cycles: Energy and Exergy Viewpoints, International Journal of Engineering (IJE), IJE TRANSACTIONS A: Basics Vol. 28, No. 4, (April 2015) 618-626